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(54) **DISK DRIVE MAGNETIC READ HEAD WITH AFFIXED AND RECESSED LASER DEVICE**

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(52) **U.S. Cl.**
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369/13.13, 13.12, 13.02; 360/59, 125.31
See application file for complete search history.

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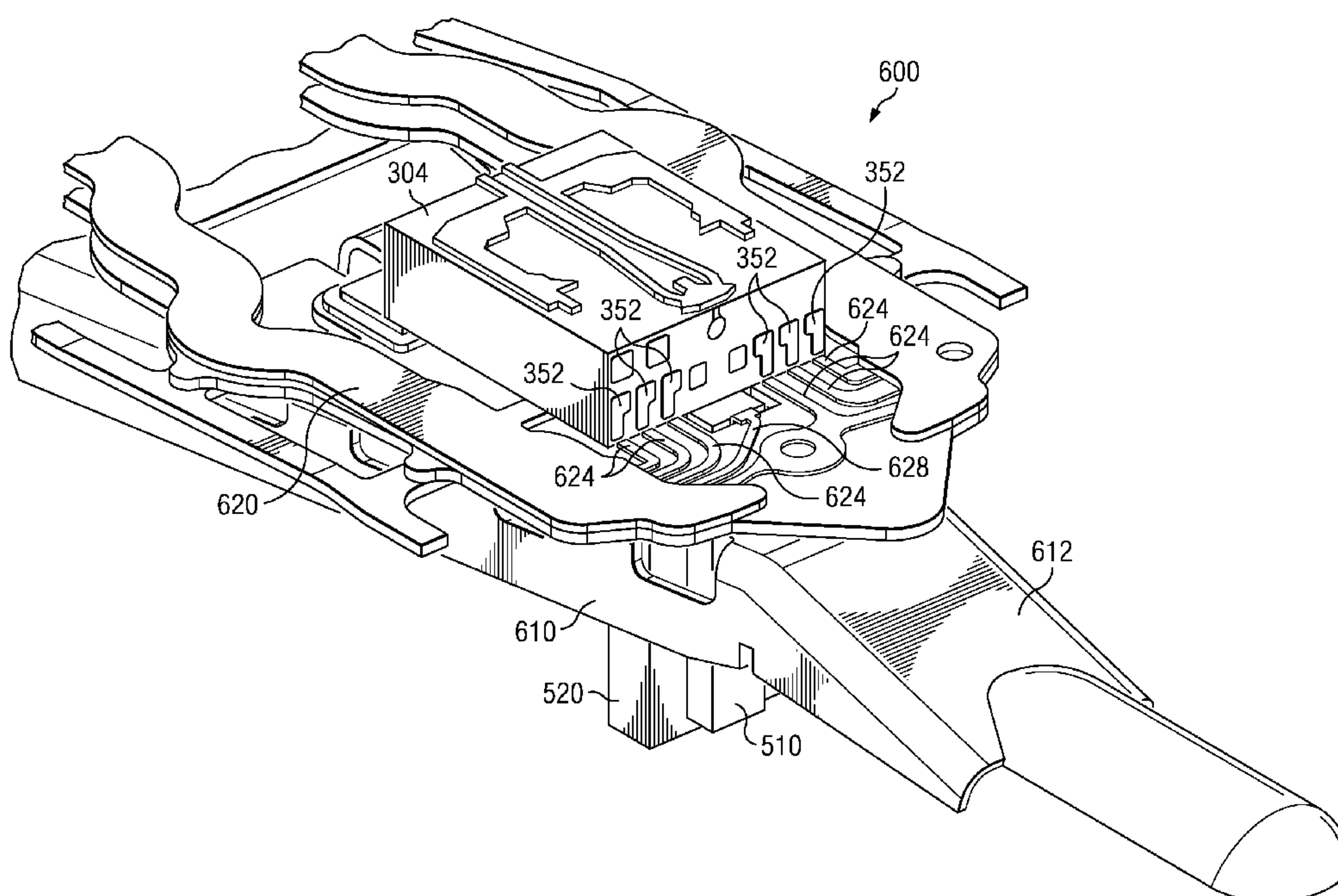
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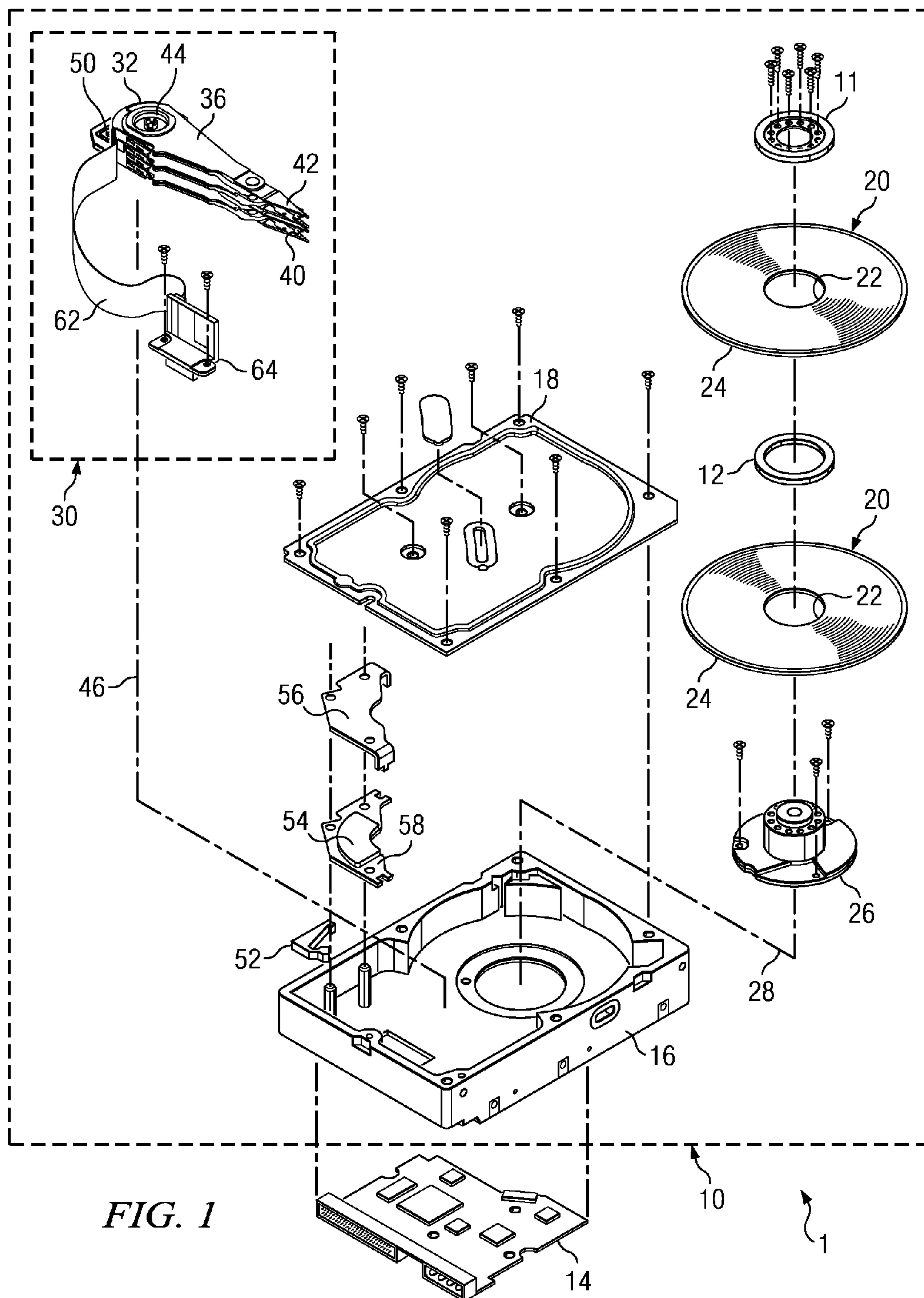
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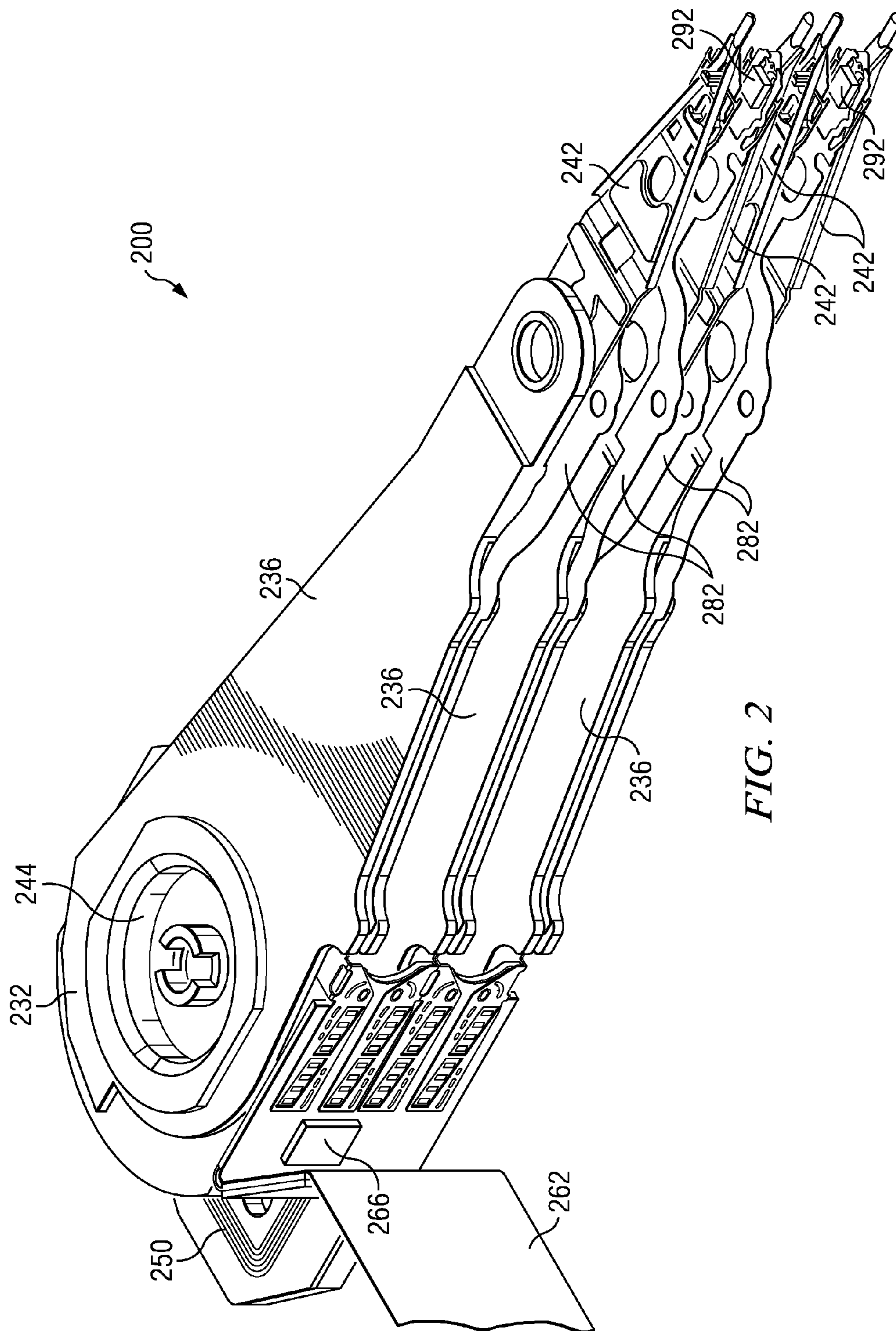
(57) **ABSTRACT**

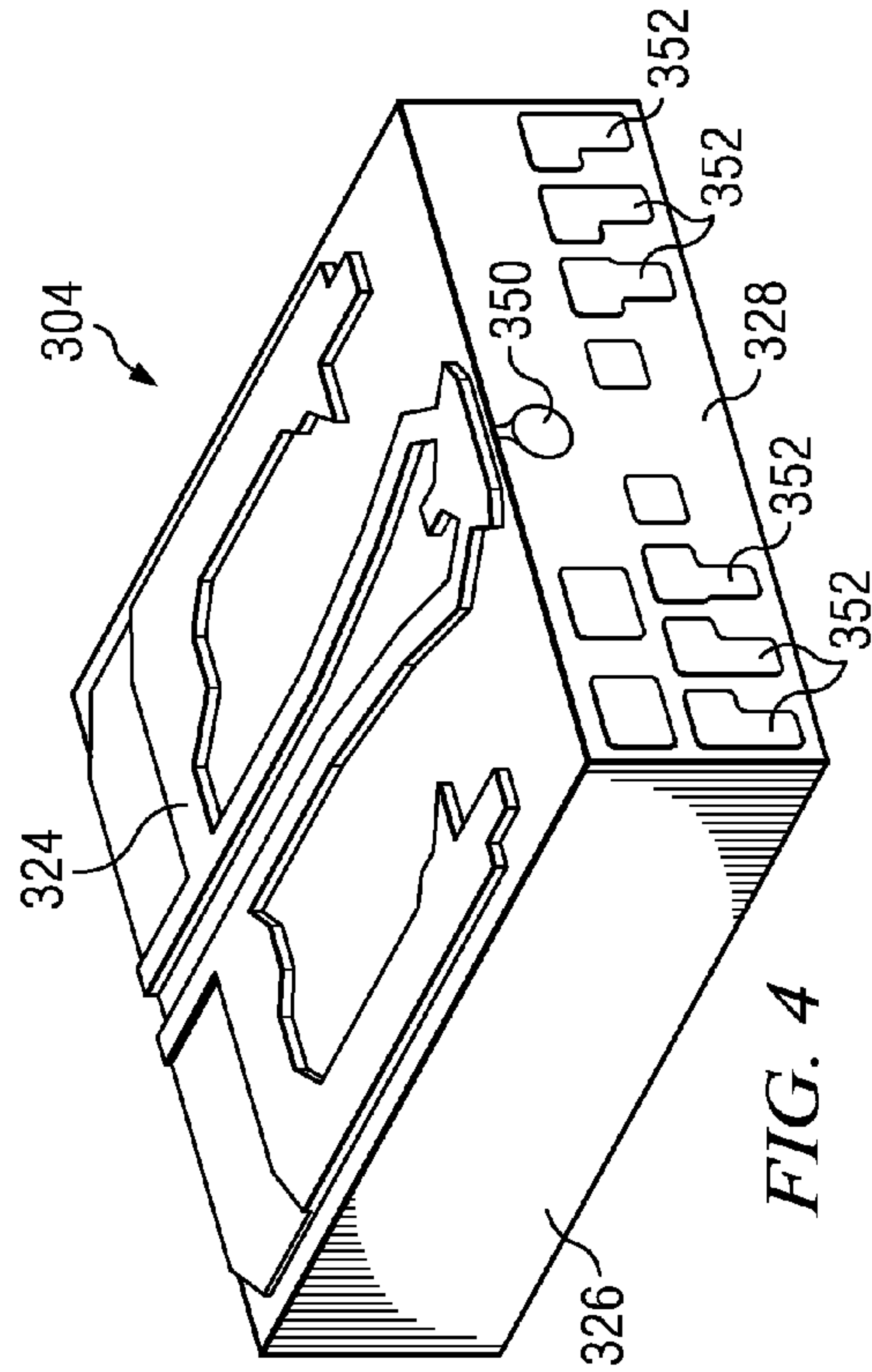
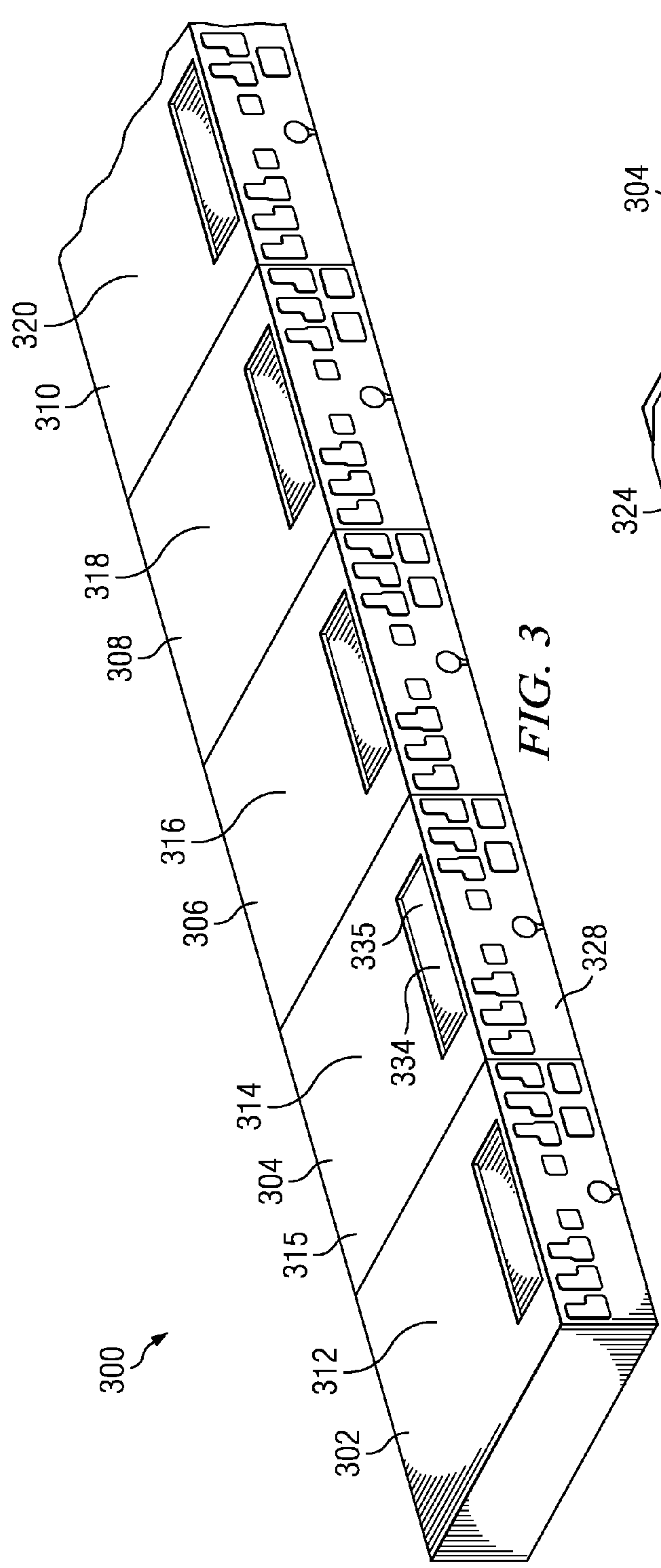
A disk drive read head includes a slider. The slider has an air bearing surface, a trailing face, and a mounting face opposite the air bearing surface. The mounting face includes a mounting face recession. An interior surface of the mounting face recession includes an electrically conductive terminal. The read head also includes a magnetic transducer disposed on the trailing face of the slider. The read head also includes a laser device affixed to the electrically conductive terminal by a solder material. The laser device is at least partially recessed into the mounting face recession.

17 Claims, 6 Drawing Sheets









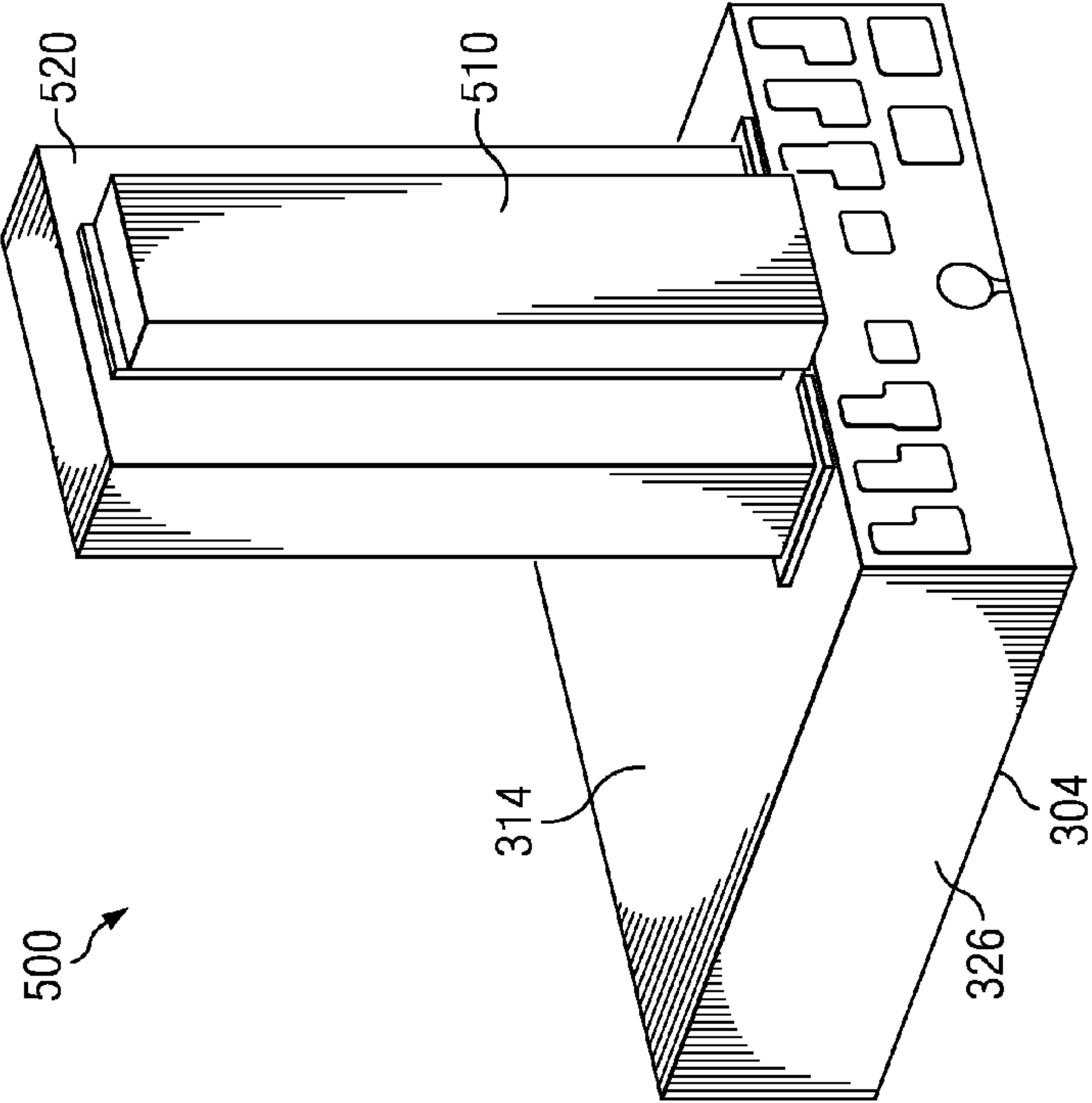


FIG. 5B

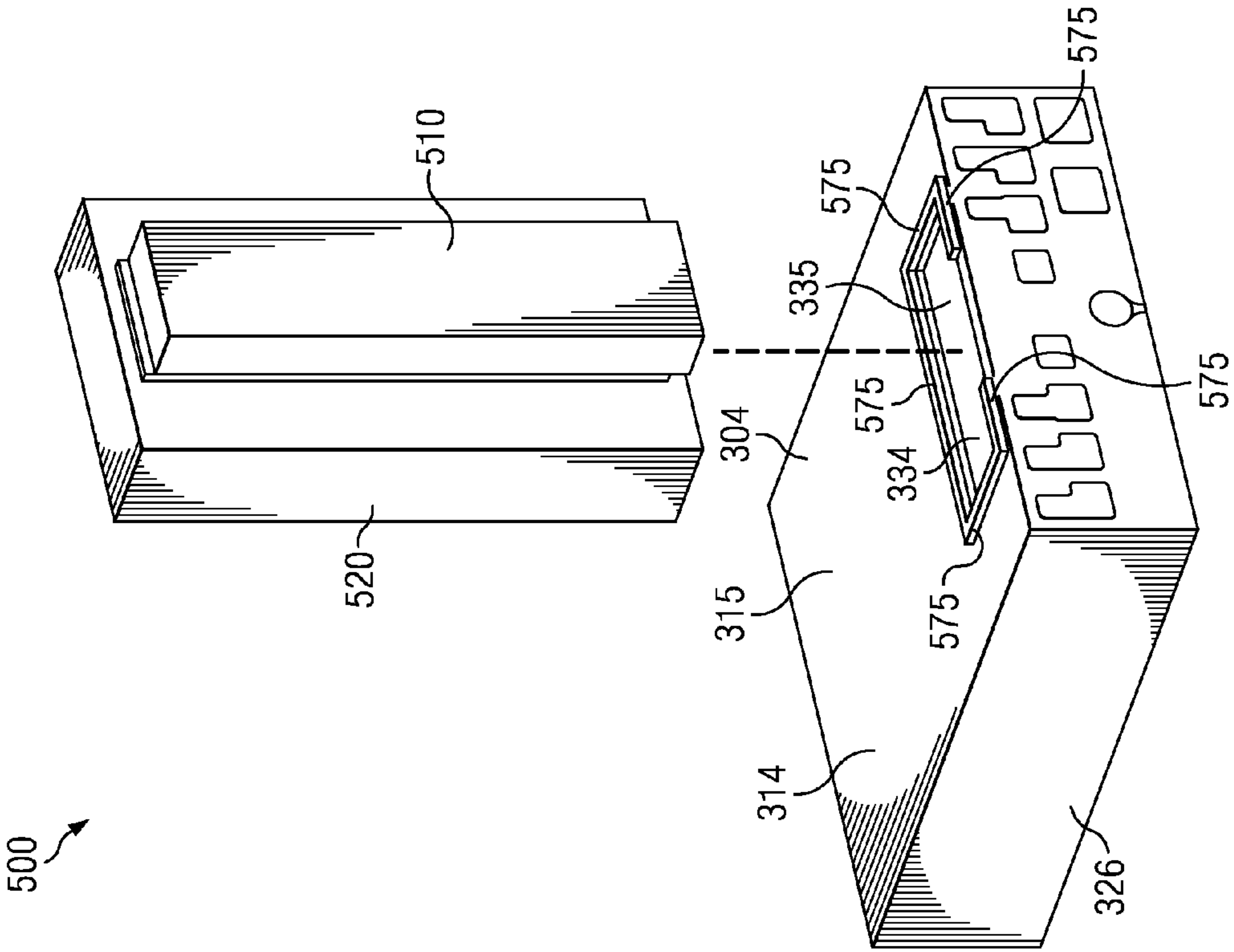
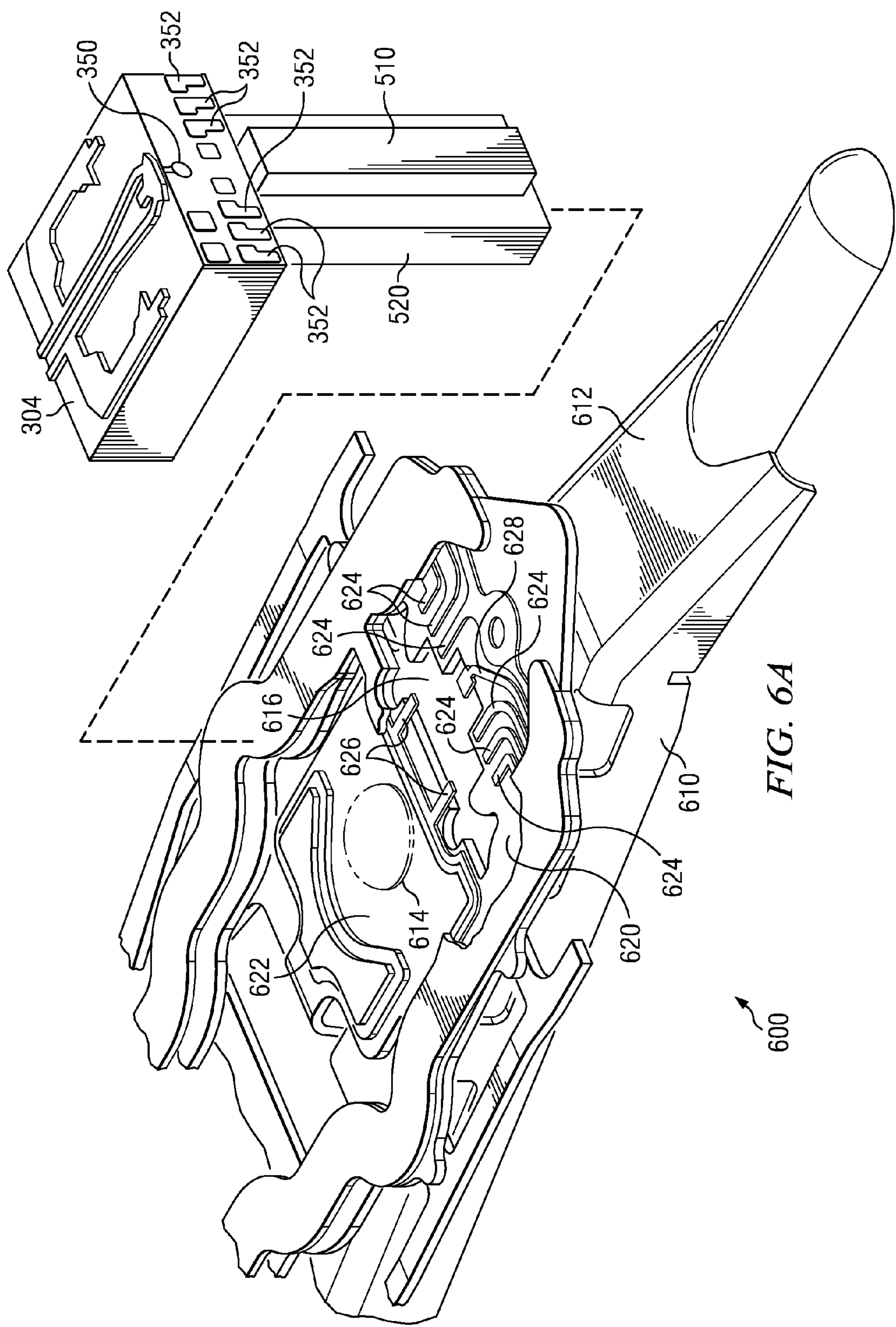


FIG. 5A



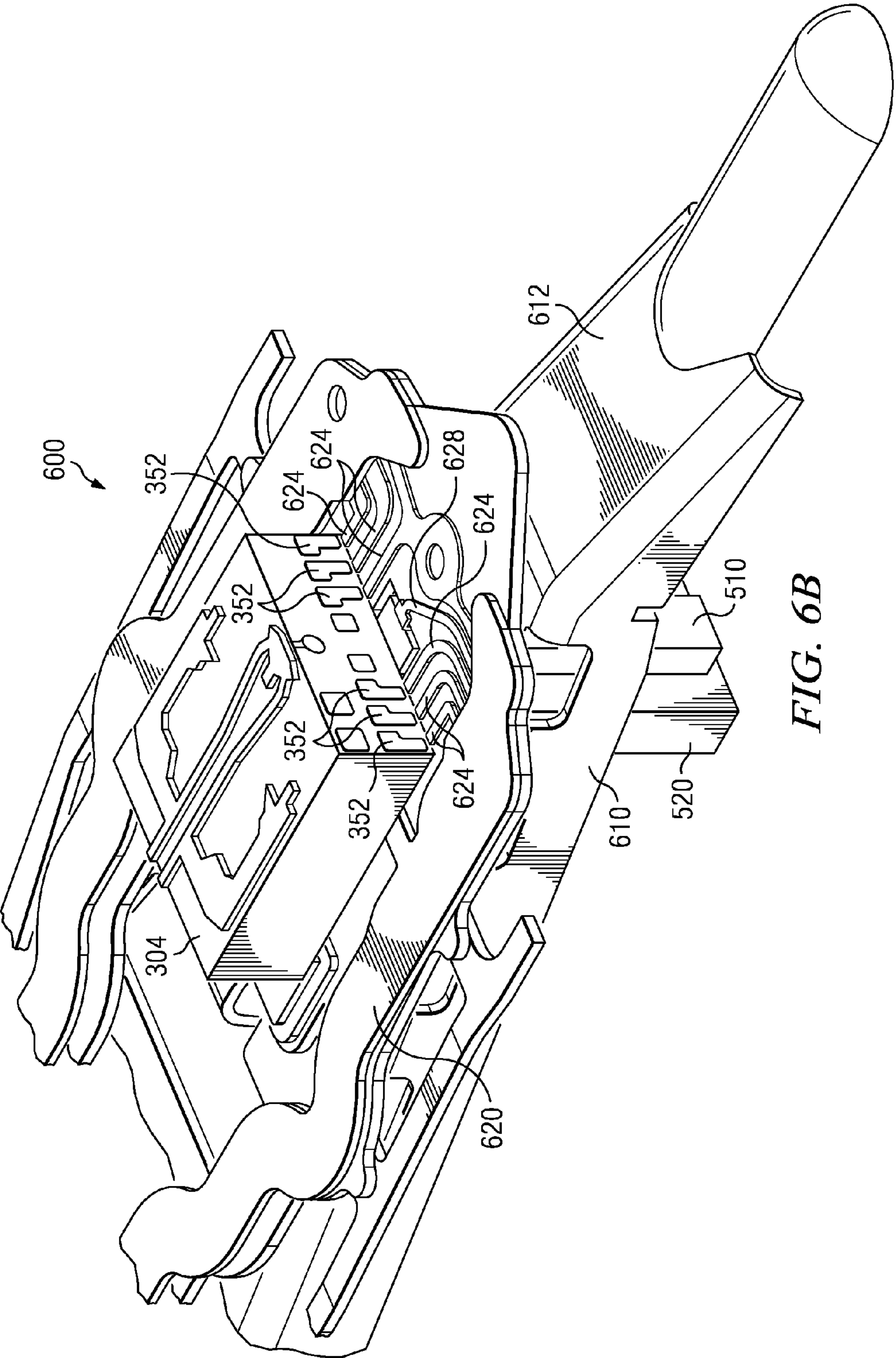


FIG. 6B

DISK DRIVE MAGNETIC READ HEAD WITH AFFIXED AND RECESSED LASER DEVICE

BACKGROUND

Magnetic hard disk drives retrieve and/or store data in computers and other consumer electronics devices. A magnetic hard disk drive includes one or more heads that can read and write information on a corresponding magnetic surface of a spinning disk. For convenience, all heads that can read are referred to as “read heads” or “heads” herein, regardless of other devices and functions the read head may also perform (e.g. writing, micro-actuation, flying height control, touch down detection, lapping control, localized disk media heating, etc). Each read head is a sub-component of a head gimbal assembly (HGA). The HGA also includes a suspension assembly for holding the head and providing a plurality of electrical connections thereto. The suspension assembly typically includes a fragile laminated flexure to carry the electrical signals to and from the head.

The head typically comprises a slider that includes an air bearing surface (ABS) that faces the magnetic disk surface, a trailing face, and a mounting face that is opposite the ABS and that faces away from the ABS. A magnetic sensor and a plurality of head bond pads are typically disposed on the trailing face of the slider. The mounting face of the slider is typically permanently bonded to a tongue portion of the fragile laminated flexure by an adhesive, in a position such that the plurality of head bond pads are aligned with corresponding bond pads on the laminated flexure.

Conventionally, the head writes tiny magnetic transitions on the magnetic disk surface by applying sufficient magnetic field to the desired microscopic disk surface location to overcome the coercivity of the disk surface material there, and thereby change the remnant field there. However, market demand for disk drives having ever higher data storage capacity has motivated investigation into the possible use of “energy assisted” magnetic recording (EAMR), in which writing is accomplished not only by local application of a magnetic field, but also by local application of laser light for localized heating of the disk surface. EAMR may enable the writing of smaller transitions, and thereby increase the areal density of data stored on the disk surface.

Most proposed EAMR technologies require the addition of a laser light source on the read head, for example bonded to the back face of the slider. The laser light source must be attached to the read head in a precisely controlled position relative to the magnetic sensor. However, conventional structures and methods for attachment of a laser light source for EAMR to a read head may result in unacceptable relative position uncertainty or attachment unreliability. For example, solder or adhesive may permit the laser light source to undesirably move relative to the magnetic sensor before solder or adhesive hardening, and/or undesirably separate afterwards. Accordingly, there is a need in the art for improved structures and methods to attach a laser light source for EAMR to a read head.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an exploded perspective view of a disk drive capable of including an embodiment of the present invention.

FIG. 2 is a top perspective view of a head stack assembly (HSA), according to an embodiment of the present invention.

FIG. 3 depicts a row of heads according to an embodiment of the present invention, after the row is cut from a wafer but

before individual heads are cut from the row, as viewed from a perspective angle towards the mounting surfaces of the heads.

FIG. 4 depicts a head capable of use with an embodiment of the present invention, as viewed from a perspective angle towards the air bearing surface of the head.

FIG. 5A is a perspective view of a head-laser submount assembly (HLSA) according to an embodiment of the present invention, having a laser device exploded away from the mounting surface of the head.

FIG. 5B is a perspective view of the HLSA of FIG. 5A, except with the laser device attached to the mounting surface of the head.

FIG. 6A is a perspective view of the distal portion of a head gimbal assembly (HGA) according to an embodiment of the present invention, with a head (with mounted laser device) being exploded away from the suspension assembly.

FIG. 6B is a perspective view of the distal portion of a head gimbal assembly (HGA) of FIG. 6A, except with the head being attached to a tongue of the suspension assembly.

DESCRIPTION OF EXAMPLE EMBODIMENTS

FIG. 1 is a perspective view of a disk drive 1 capable of including an embodiment of the present invention. The disk drive 1 includes a head disk assembly (HDA) 10 and a printed circuit board (PCB) 14. The HDA 10 includes a disk drive base 16 and a disk drive cover 18, that together enclose other components of the HDA 10. At least one disk 20 is rotatably mounted to the disk drive base 16 by a spindle motor 26. The HDA 10 optionally includes one or more additional disks 20, also rotatably mounted to the disk drive base 16 by spindle motor 26, with the disks 20 then separated by one or more spacer rings 12.

The disks 20 may comprise an aluminum, glass, or ceramic substrate, with the substrate optionally being coated with a NiP under-layer, at least one thin-film magnetic layer, a diamond-like amorphous carbon protective layer, and a very thin lubricant layer, for example. The disks 20 are annular in shape, having an outer periphery 24 and an inner periphery 22, and may be clamped to a rotating hub of the spindle motor 26, by a clamp 11. The rotating hub of the spindle motor 26 rotates the disks 20 about a disk axis of rotation 28.

The HDA 10 also includes a head stack assembly (HSA) 30 that includes an actuator 32 that is pivotably mounted to the disk drive base 16 by a pivot bearing 44 that is inserted as a cartridge into a bore in the actuator 32. The pivot bearing 44 allows the actuator 32 to pivot about an actuator pivot axis 46. The actuator 32 may be fabricated from aluminum, magnesium, beryllium, or stainless steel. The pivot bearing 44 may be retained in the bore by a tolerance ring or may be otherwise retained (e.g. by an adhesive). The angular range of motion of the actuator 32 may be limited by a latch and crash stop mechanism 52. The actuator 32 includes at least one actuator arm 36 that extends away from the pivot bearing 44, and an actuator coil 50 that extends away from the pivot bearing 44 in a direction generally opposite the actuator arm 36.

The actuator coil 50 may fit in a yoke structure that optionally comprises a top plate 56 and a bottom plate 58, to form a voice coil motor (VCM). One or both of the top plate 56 and the bottom plate 58 may support a permanent magnet(s) of the VCM (e.g. permanent magnet 54). The top plate 56 and/or the bottom plate 58 preferably comprise a ferromagnetic metal so as to provide a return path for magnetic flux from the permanent magnet(s) through the yoke structure. The ferromagnetic metal yoke structure including the top plate 56 and the bottom

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plate **58** is preferably affixed to the disk drive base **16**, for example by an adhesive, one or more fasteners, and/or magnetic attraction.

A plurality of head gimbal assemblies **42** may be attached to arms **36** of the actuator **32**, for example by swaging. A flexible printed circuit (FPC) **62** (also known as a “flex cable”) may also be attached to the actuator **32**. Each of the head gimbal assemblies **42** may include a read head **40** that is bonded to a laminated flexure having a flexure tail that is electrically connected to the FPC **62**. The FPC **62** can communicate electrical signals, via these electrical connections and via a flex bracket **64**, between the head gimbal assemblies **42** and an external electronic system that is disposed on the PCB **14**.

The actuator **32**, head gimbal assemblies **42**, and FPC **62** all may be considered as components of the HSA **30**. The HDA **10** may have additional components that are not shown in FIG. **1**. For example, the HDA **10** may also include a conventional head loading ramp (not shown), that may be positioned adjacent the disks **20** to facilitate merging of the head gimbal assemblies **42** onto surfaces of the disks **20**.

FIG. **2** is a top perspective view of a head stack assembly (HSA) **200**, according to an embodiment of the present invention. The HSA **200** includes an actuator **232** pivotably attachable to a disk drive base by a pivot bearing **244** that is inserted as a cartridge into a bore in the actuator **232**. The actuator **232** may be fabricated from a suitable metal such as aluminum, magnesium, beryllium, or stainless steel, or a relatively low mass density non-metallic or composite material having sufficient stiffness. The pivot bearing **244** may be retained in the bore by a tolerance ring or may be otherwise retained (e.g. by an adhesive). The actuator **232** includes a plurality of actuator arms **236** that extends away from the pivot bearing **244**, and an actuator coil **250** that extends away from the pivot bearing **244** in a direction generally opposite the actuator arms **236**.

In the embodiment of FIG. **2**, a plurality of head gimbal assemblies (HGAs) **242** are shown to be attached to arms **236** of the actuator **232**. Each HGA includes a read head **292** and a suspension assembly to which the read head **292** is attached. Specifically, each read head **292** is attached and electrically connected to a laminated flexure **282** of the suspension assembly of the HGA **242**. The suspension assembly of each HGA **242** is shown to be attached to one of the actuator arms **236**, for example by swaging. A flexible printed circuit (FPC) **262** is also shown to be attached to the actuator **232**. Each laminated flexure **282** includes a plurality of conductive traces, and each laminated flexure **282** has a flexure tail that extends to the FPC **262**, where the plurality of conductive traces is connected to the FPC **262** near a pre-amplifier chip **266**.

FIG. **3** depicts a row **300** of read heads (including heads **302**, **304**, **306**, **308**, **310**), according to an embodiment of the present invention, as viewed from a perspective angle towards the mounting surfaces (including heads **312**, **314**, **316**, **318**, **320**) of the read heads. The row **300** of FIG. **3** is depicted after the row **300** is cut from a wafer (not shown) but before individual read heads (including read heads **302**, **304**, **306**, **308**, **310**) are cut from the row **300**. FIG. **4** depicts the read head **304** after it is cut from the row **300**, as viewed from a perspective angle towards the air bearing surface **324** of the read head **304**. The read head **304** is representative of the other read heads in the row **300** (e.g. heads **312**, **316**, **318**, **320**).

Now referring to the embodiment of FIGS. **3** and **4**, the read head **304** comprises a slider **326** which includes the air bearing surface **324**, a trailing face **328** that is normal to the air bearing surface **324**, and the mounting face **314** (which is opposite but substantially parallel to the air bearing surface

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324). The air bearing surface **324** may be of any conventional design, and is not restricted to the design shown in FIG. **4**. The head **304** also comprises a plurality of head bond pads **352** that are disposed on the trailing face **328** and that are electrically conductive. The head bond pads **352** may comprise gold and/or copper, for example.

A magnetic transducer **350** is disposed on the trailing face of the slider **326**. The magnetic transducer **350** may include a magneto-resistive read sensor (e.g. a tunneling magneto-resistive read sensor) and a magneto-inductive write transducer, for example. The slider **326** may comprise a ceramic material such as AlTiC, for example.

In the embodiment of FIG. **3**, the mounting face **314** includes a mounting face recession **334**. The mounting face recession **334** includes an interior surface **335** that is recessed relative to a major surface **315** of the mounting face **314** that is outside of the mounting face recession **334**. The interior surface **335** preferably but not necessarily includes a metal coating, for example a metal coating to which solder can bond strongly. For example, the metal coating on the interior surface **335** may comprise a layer of gold or platinum having a thickness in the range 100 nm to 250 nm. Conductive adhesive may be used in place of the metal coating on the interior surface **335**.

In the embodiment of FIGS. **5A** and **5B**, The depth of the mounting face recession **334** is preferably but not necessarily in the range 0.3 to 0.5 microns, measured from and normal to an adjacent region of the major surface **315** of the mounting face **314** that is outside the mounting face recession **334**. In certain embodiments, the depth of the mounting face recession **334** is preferably not made deeper than this range, so that the mounting face recession **334** is less likely to adversely affect the desired crown or camber of the slider **326**. Preferably, not more than half of the mounting face recession depth is filled with the metal coating on the interior surface **335**.

FIG. **5A** is a perspective view of a head-laser submount assembly (HLSA) **500** according to an embodiment of the present invention, having a laser device (e.g. a laser diode **510** with submount **520**) exploded away from the mounting surface **314** of the head **304**. FIG. **5B** is a perspective view of the HLSA of FIG. **5A**, except with the laser device (e.g. a laser diode **510** with submount **520**) attached to the mounting surface **314** of the head **304**. Specifically, in the embodiment of FIG. **5B** the laser submount **520** is affixed to the interior surface **335** of the mounting face recession **334** in the mounting surface **314** by a bonding material (e.g. solder), so that the laser submount **520** is at least partially recessed into the mounting face recession **334**. Preferably but not necessarily, the solder material (e.g. tin solder) defines a solder material thickness in the range 1 micron to 2.5 microns.

In the embodiment of FIG. **5A**, the mounting face recession **334** includes a plurality of recession edges **575**. Preferably but not necessarily, a maximum clearance between the laser submount **520** and a nearest one of the plurality of recession edges **575** is less than 10 microns. For example, if the face of the laser submount **520** that faces the mounting face recession **334** is rectangular with 200×400 microns dimensions, then the dimensions of the mounting face recession **334** preferably but not necessarily does not exceed 220×420 microns.

In certain embodiments, it is desired that the bonding material (e.g. solder) does not extend beyond any of the plurality of recession edges **575**, for example to prevent contamination of other areas of the head **304**. Also, in certain embodiments, the structural features and/or dimensional ranges or inequalities described in the previous two paragraphs may provide improved relative position certainty or attachment reliability

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relative to conventional structures and methods for attachment of a laser light source for EAMR to a read head.

FIG. 6A is a perspective view of the distal portion of a head gimbal assembly (HGA) 600 according to an embodiment of the present invention, with a head 304 (and mounted laser diode 510 and laser submount 520) being exploded away from a suspension assembly 610 of the HGA 600. FIG. 6B is a perspective view of the distal portion of the HGA 600 of FIG. 6A, except with the head 304 being attached to a tongue 622 of the suspension assembly 610.

Now referring to the embodiment of FIGS. 6A and 6B, the suspension assembly 610 comprises a load beam 612 and a flexure 620. The flexure 620 includes a tongue 622 on which the read head 304 may be mounted. A first side of the tongue 622 may be in contact with the load beam 612, for example via a conventional dimple 614 that transfers a preload force (also known as a “gram load”) from the load beam 612 to the head 304 to preload the head 304 against the surface of a rotating disk during disk drive operation.

Still referring to the embodiment of FIGS. 6A and 6B, the flexure 620 is a laminar flexure that includes a patterned electrically conductive layer that has six conductive traces 624, two conductive traces 626, and a conductive trace 628. The conductive traces may comprise copper, for example. The magnetic transducer 350 is electrically accessed through a subset of the head bond pads 352. Each of the head bond pads 352 is preferably electrically connected to a respective one of the conductive traces 624 by a conductive ball (not shown), for example by gold ball bonding or other applicable conventional methods. Hence, in the embodiment of FIG. 6A, the magnetic transducer 350 is electrically connected to a subset of the conductive traces 624, but is not connected to the conductive traces 626 or 628.

As shown in FIGS. 6A and 6B, the laser diode 510 passes through the opening 616 in the suspension assembly 610, and the laser diode 510 is electrically connected to (by making electrical contact with) at least the conductive trace 628, but is not connected to the conductive traces 624. The laser diode 510 may be electrically connected to the conductive traces 626, via a conductive path on or through the laser submount 520 that contacts the conductive traces 626. The conductive traces 624, 626, and 628 extend along the flexure 620, via an elongated flexure tail to electrical connections with an actuator flexible printed circuit (e.g. FPC 262, as shown in FIG. 2).

In the foregoing specification, the invention is described with reference to specific exemplary embodiments, but those skilled in the art will recognize that the invention is not limited to those. It is contemplated that various features and aspects of the invention may be used individually or jointly and possibly in a different environment or application. The specification and drawings are, accordingly, to be regarded as illustrative and exemplary rather than restrictive. For example, the word “preferably,” and the phrase “preferably but not necessarily,” are used synonymously herein to consistently include the meaning of “not necessarily” or optionally. “Comprising,” “including,” and “having,” are intended to be open-ended terms.

We claim:

1. A read head comprising:

a slider having an air bearing surface, a trailing face that is normal to the air bearing surface, and a mounting face that is opposite but substantially parallel to the air bearing surface, the mounting face including a mounting face recession, the mounting face recession including an interior surface that is recessed relative to a major surface of the mounting face that is outside of the mounting face recession;

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a magnetic transducer disposed on the trailing face of the slider; and

a laser device affixed to the interior surface by a bonding material, the laser device being at least partially recessed into the mounting face recession;

wherein the major surface of the mounting face substantially surrounds the mounting face recession, and wherein the interior surface includes a metal coating that comprises gold or platinum.

2. A read head comprising:

a slider having an air bearing surface, a trailing face that is normal to the air bearing surface, and a mounting face that is opposite but substantially parallel to the air bearing surface, the mounting face including a mounting face recession, the mounting face recession including an interior surface that is recessed relative to a major surface of the mounting face that is outside of the mounting face recession;

a magnetic transducer disposed on the trailing face of the slider; and

a laser device affixed to the interior surface by a bonding material, the laser device being at least partially recessed into the mounting face recession;

wherein a depth of the mounting face recession is in the range 0.3 to 0.5 microns, measured from and normal to an adjacent region of the major surface.

3. A read head comprising:

a slider having an air bearing surface, a trailing face that is normal to the air bearing surface, and a mounting face that is opposite but substantially parallel to the air bearing surface, the mounting face including a mounting face recession, the mounting face recession including an interior surface that is recessed relative to a major surface of the mounting face that is outside of the mounting face recession;

a magnetic transducer disposed on the trailing face of the slider; and

a laser device affixed to the interior surface by a bonding material, the laser device being at least partially recessed into the mounting face recession;

wherein the interior surface includes a metal coating; and wherein the metal coating comprises a layer of gold having a thickness in the range 100 nm to 250 nm.

4. A read head comprising:

a slider having an air bearing surface, a trailing face that is normal to the air bearing surface, and a mounting face that is opposite but substantially parallel to the air bearing surface, the mounting face including a mounting face recession, the mounting face recession including an interior surface that is recessed relative to a major surface of the mounting face that is outside of the mounting face recession;

a magnetic transducer disposed on the trailing face of the slider; and

a laser device affixed to the interior surface by a bonding material, the laser device being at least partially recessed into the mounting face recession;

wherein the mounting face recession defines a plurality of recession edges, and wherein a maximum clearance between the laser device and a nearest one of the plurality of recession edges is less than 10 microns.

5. The read head of claim 4, wherein the bonding material does not extend beyond any of the plurality of recession edges.

6. A disk drive comprising:

a disk drive base;

a disk rotably attached to the disk drive base;

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an actuator pivotably attached to the disk drive base, the actuator including an arm;
 a suspension assembly attached to the arm, the suspension assembly including a flexure having a plurality of conductive traces;
 a read head mounted on the flexure, the read head including a slider having an air bearing surface, a trailing face that is normal to the air bearing surface, and a mounting face that is opposite but substantially parallel to the air bearing surface, the mounting face including a mounting face recession, the mounting face recession including an interior surface that is recessed relative to a major surface of the mounting face that is outside of the mounting face recession;
 a magnetic transducer disposed on the trailing face of the slider; and
 a laser device affixed to the interior surface by a bonding material, the laser device being at least partially recessed into the mounting face recession;
 wherein the laser device passes through an opening in the flexure.

7. The disk drive of claim 6, wherein the interior surface includes a metal coating that comprises gold or platinum.

8. The disk drive of claim 6, wherein the bonding material is a solder material.

9. A disk drive comprising:
 a disk drive base;
 a disk rotably attached to the disk drive base;
 an actuator pivotably attached to the disk drive base, the actuator including an arm;
 a suspension assembly attached to the arm, the suspension assembly including a flexure having a plurality of conductive traces;
 a read head mounted on the flexure, the read head including a slider having an air bearing surface, a trailing face that is normal to the air bearing surface, and a mounting face that is opposite but substantially parallel to the air bearing surface, the mounting face including a mounting face recession, the mounting face recession including an interior surface that is recessed relative to a major surface of the mounting face that is outside of the mounting face recession;
 a magnetic transducer disposed on the trailing face of the slider; and
 a laser device affixed to the interior surface by a bonding material, the laser device being at least partially recessed into the mounting face recession;
 wherein a depth of the mounting face recession is in the range 0.3 to 0.5 microns, measured from and normal to an adjacent region of the major surface.

10. A disk drive comprising:
 a disk drive base;
 a disk rotably attached to the disk drive base;
 an actuator pivotably attached to the disk drive base, the actuator including an arm;
 a suspension assembly attached to the arm, the suspension assembly including a flexure having a plurality of conductive traces;
 a read head mounted on the flexure, the read head including a slider having an air bearing surface, a trailing face that is normal to the air bearing surface, and a mounting

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face that is opposite but substantially parallel to the air bearing surface, the mounting face including a mounting face recession, the mounting face recession including an interior surface that is recessed relative to a major surface of the mounting face that is outside of the mounting face recession;
 a magnetic transducer disposed on the trailing face of the slider; and
 a laser device affixed to the interior surface by a bonding material, the laser device being at least partially recessed into the mounting face recession;
 wherein the interior surface includes a metal coating; and
 wherein the metal coating comprises a layer of gold having a thickness in the range 100 nm to 250 nm.

11. The disk drive of claim 8, wherein the solder material defines a solder material thickness in the range 1 micron to 2.5 microns.

12. A disk drive comprising:
 a disk drive base;
 a disk rotably attached to the disk drive base;
 an actuator pivotably attached to the disk drive base, the actuator including an arm;
 a suspension assembly attached to the arm, the suspension assembly including a flexure having a plurality of conductive traces;
 a read head mounted on the flexure, the read head including a slider having an air bearing surface, a trailing face that is normal to the air bearing surface, and a mounting face that is opposite but substantially parallel to the air bearing surface, the mounting face including a mounting face recession, the mounting face recession including an interior surface that is recessed relative to a major surface of the mounting face that is outside of the mounting face recession;
 a magnetic transducer disposed on the trailing face of the slider; and
 a laser device affixed to the interior surface by a bonding material, the laser device being at least partially recessed into the mounting face recession;
 wherein the mounting face recession defines a plurality of recession edges, and wherein a maximum clearance between the laser device and a nearest one of the plurality of recession edges is less than 10 microns.

13. The disk drive of claim 12, wherein the bonding material does not extend beyond any of the plurality of recession edges.

14. The disk drive of claim 6, wherein the suspension assembly further includes a load beam, and wherein the laser device passes through an opening in the load beam.

15. The disk drive of claim 6, wherein the laser device is a sub-mount assembly that includes a laser diode.

16. The disk drive of claim 6, wherein the plurality of conductive traces includes at least first, second, and third conductive traces, the magnetic transducer being electrically connected to at least the first and second conductive traces but not to the third conductive trace.

17. The disk drive of claim 16, wherein the laser device is electrically connected to at least the third conductive trace, but not to the first or second conductive traces.

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